printed, with each swath being printed by a respective block of print elements and being wider than a swath produced by a single print element. Kondo also does not disclose printing further swaths which at least partially overprint previously printed swaths in a further relative traverse. Therefore, none of these recitations of claims 1, 2, and 17 is taught or suggested by Kondo.

Accordingly, independent method claim 1 and independent apparatus claims 2 and 17 are not rendered obvious by the teachings of Kondo. As a result, dependent claims 3-16 and 18-40 are also not rendered obvious by the teachings of Kondo.

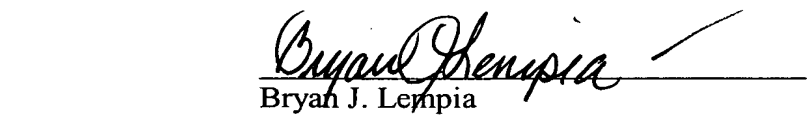
CONCLUSION

Claims 1-40 are currently pending in the application. By the present response, the applicant believes that each of the objections and claim rejections is traversed. It is believed that each of claims 1-40 is in condition for allowance. Reconsideration is hereby respectfully solicited.

The examiner is invited to contact the undersigned at the telephone number listed below in order to discuss any remaining issues or matters of form that may move this case toward an allowance.

Respectfully submitted,

MARSHALL, O'TOOLE, GERSTEIN,
MURRAY & BORUN
6300 Sears Tower
233 South Wacker Drive
Chicago, Illinois 60606-6402
(312) 474-6300



Bryan J. Lempia
Reg. No. 39,746
Attorney for Applicant

May 16, 2001

JP 4-10948 (A)

Int. Cl[5]
B 41 J 2/21
2/045
2/055

Identification code:

Patent Office Reference Number
8703-2C
9012-2C

43. Published: 16 January 1992

Examination request: Not made Number of inventions: 8 (Total pages: 6)

54. Title of invention: Colour inkjet printer

21. Patent application: *Hei* 2-113005

22. Application date: 27 April 1990

72. Inventor: KONDO Tokumasa
Hitachi Koki Kabushiki Kaisha
1060 Takeda, Katsuta-shi, Ibaraki

71. Applicant: Hitachi Koki Company Limited
6-2 Otemachi 2-chome, Chiyoda-ku, Tokyo

Specification

1. Title of Invention

Colour inkjet printer.

2. Claims

1. A colour inkjet printer characterised in that
it is an on-demand colour inkjet printer fitted with multiple piezoelectric elements corresponding to multiple nozzles
and in that the array of the nozzles is such that one unit comprises nozzles of four different colours, a yellow ink nozzle, magenta ink nozzle, cyan ink nozzle and black ink nozzle, and multiple nozzle groups are arranged in a row.

2. A colour inkjet printer, according to Claim 1, characterised in that the said heads are formed of laminated thin etched sheets and that the ink supply channels of the said etched

part are formed by half-etching.

3. A colour inkjet printer, according to Claim 1, characterised in that the configuration of the nozzles is such that one nozzle unit comprises eight nozzles, one each of dark yellow, pale yellow, dark magenta, pale magenta, dark cyan, pale cyan, dark black and pale black and in that these nozzle units are arranged in a line of multiple units.

4. A colour inkjet printer, according to Claim 1, characterised in that it is provided with a carrier on which the said head is fitted and which supplies ink, and a drive means that moves the said carrier horizontally over a distance slightly greater than the distance from a yellow nozzle to the next yellow nozzle.

5. A colour inkjet printer, according to Claim 1, characterised in that it has an ink tank and colour ink in this ink tank and an ink distribution means that feeds the said colour ink on demand to the ink supply aperture of each nozzle in the said colour inkjet printer head.

6. A colour inkjet printer, according to Claim 1, characterised in that the said ink distribution means is formed by laminating thin etched sheets.

7. A colour inkjet printer, according to Claim 1, characterised in that it is fitted with a drive means that moves the horizontal travel of the said ink distribution means over a distance slightly greater than the distance from a yellow nozzle to the next yellow nozzle.

8. A colour inkjet printer, according to Claim 1, characterised in that the vertical section of the ink chamber is rectangular and the piezo element attached in a position opposite the said ink chambers is also rectangular.

3. Detailed Description of the Invention

(Area of use for the invention)

The present invention relates to an on-demand colour inkjet printer.

(Background to the invention)

Figures 7 and 8 show examples of the prior art.

An on-demand inkjet head, as shown in Figure 7, comprises a very simple structure in which there is an ink chamber 102 filled with ink, a piezo element 104 which exerts pressure on the ink chamber 102, and volumetric changes of ink chamber 102 are used to produce ink droplets through orifice 101. This structure may, for example, comprise three layers, thin etched sheets 105a~105c, as shown in Figure 8. The design is also such that there are multiple nozzles for each colour to carry out colour printing. In the figure, ink can be fed from yellow ink supply aperture 106 to four nozzles.

The problems involved with this head include the fact that the increase in the number of

single colour nozzles causes an increase in the size of the head and in the size of the drive mechanism for the head. Also, since the distance of head travel is (print width + two-fold the head width), appropriate acceleration and deceleration must be applied when it is returned. Since the greater the head drive frequency is, the greater must be the acceleration and deceleration, any increase in frequency designed to shorten the printing time results in an increase in the size of the device. Further, if the device is increased in size to achieve an increase in frequency, this causes the problem of increased drive noise when the head is returned, which acts against the quietness of operation that is one of the selling points of the inkjet printer.

One proposed means of addressing these problems is to have the head in the form of a row of nozzles and move this in a shuttle fashion. A shuttle-type inkjet is proposed in JP 51-94725 and JP 48-59731 proposes a technique for nozzles to be arranged in a line but there is no such technology for a colour printer. If the head is assembled with a configuration in which nozzles are simply arranged in a line for one colour, with nozzles for other colours ranged above it, then if the memory necessary for the printer is 1 for the lower row of nozzles, it is least two-fold for the upper row (if the vertical difference is one dot; if this is five dots, then a five-fold size of memory is required) and a further three-fold for another upper row (and if the vertical difference is five dots, the memory required is 5+5 = 10). Thus, there is a considerable increase in the memory size required. One possible attempt to address this problem is to position colour nozzles in a single row, but since there is no technique in the prior art of providing channels to colour nozzles in a row, this attempt confronts the problem that it is not possible to produce this configuration in practice.

(Objects of the invention)

The objects of the present invention is to solve the above problems by increasing the number of nozzles fitted in the head, so that the printing time is reduced, and also to make a great reduction in the size of the device by reducing the travel of the head.

(Summary of the invention)

In the present invention the structure of the head is devised such that the number of nozzles is increased and the overall size of the device reduced, by disposing the colour ink nozzles in the head as units comprising yellow, magenta, cyan and black and configuring these in a row of multiple units and also by driving this head in a shuttle fashion.

(Embodiments of the invention)

Below, the present invention is described in greater detail with reference to Figures 1~6 and

9-11.

The first description is of the structure shown in Figures 1-4.

Paper 2 is wrapped around platen 1. Head 3 is fitted opposite to, and at a slight distance from, platen 1. 6 is a carrier fitted to head 3 which feeds ink to nozzles in the head. Carrier 6 comprises chambers 15a-15d for four different colour inks. A device (not shown) to move the head 3 parallel to platen 1 and support shaft 5 are attached to carrier 6. 4 is a piezo element.

Figure 2 shows the head 3 seen from in front of the nozzles. In this figure, the nozzles are, from the left, yellow 7Y, magenta 7M, cyan 7C and black 7BK, forming one unit, and the head comprises a row of multiple units. The width required for this structure is approximately the same as the width of paper 2.

Figure 3 shows the laminated thin sheets 8a-8i that make up the head and make possible the nozzle configuration shown in Figure 2. In sheet 8b, 11b is an ink channel, 10 is an ink branch channel and 9 is an ink chamber. An ink channel for yellow ink is formed in sheet 8b. Similarly, a magenta ink channel is formed in sheet 8d, a cyan ink channel in sheet 8f and a black ink channel in sheet 8h. Sheets 8c, 8e and 8g play the roles of walls for the ink chamber 9 and the ink channels. Figure 4 is a schematic cross-section of the yellow ink chamber shown in Figure 3. 11 is an ink channel formed by the overlapping of the ink channels of the various sheets 11b, 11c ..... 11h.

Next, the operations of the invention are described.

As shown in Figure 1, carrier 6 is capable of moving reciprocally for a distance ℓ_1 along shaft 5. In the figure, the solid line shows the position of the head 3 and carrier 6 at the left end and the dotted line shows the position of the head 3 and carrier 6 at the right end of its travel. The movement of head 3 may be such that it moves at a uniform velocity during the return movement and when engaged in printing and it may be such that it travels at a uniform velocity when printing and then returns rapidly.

The ink supply to the head 3 may be from an ink chamber in the carrier 6. In Figure 2, dimension L is the distance from a yellow nozzle to the next yellow nozzle. The distance between the nozzles is the same in all cases. If the distance of travel ℓ_1 is greater than the distance L ($\ell_1 > L$), the four colours may overlap at an optional point. The distance for change in velocity at the part where direction is reversed is also added for the total distance. A laminated nozzle is capable of achieving a printing timer shorter than that of the nozzle of the prior art. In Figure 3, the cross-section of the ink chamber 9 is rectangular. It is

preferable that it should be rectangular in order to make it possible to have multiple nozzles in the same line. In this head, the design is such that the ink chamber 9 is 5mm vertically and 1.6 horizontally and the wall between the ink chambers is 0.94mm.

The piezo element 4 opposite the ink chamber 9 is also rectangular in shape. Figure 4 shows the cross-section after lamination of the sheets shown in Figure 3. Figures 5 and 6 show other embodiments of the invention. The ink distribution channel 21 of sheets 8i, 8k, 8l and 8m is formed by half-etching (this part is shown by oblique lines in the figures). Because of this, it is possible to omit the walls (8c, 8e, 8g and 8i in Figure 3) necessary to separate the ink channels, which results in a reduction in the expense for materials and a reduction of the head weight. Figures 9~11 show other embodiments of the invention. Figure 9 shows the configuration of the ink distributor. Figure 10 shows the configuration of a head with an ink distributor. Figure 11 shows the assembly when the said distributor and head are attached.

In the figures, 31a~31i are the constituent sheets of the distributor processed into the necessary shape by etching. In sheet 31a, multiple groups of supply apertures for yellow, magenta, cyan and black ink are arrayed in a line. In sheet 31b, 33 is a channel for the distribution of yellow ink and 34 is a supply channel for yellow ink. Below, ink channels for magenta, cyan and black ink are formed between sheets 31d~31h. In sheet 31i, input sides of ink supply apertures are fitted for each of the yellow, magenta and black inks. Stainless steel is used as the material for the distributor and the sheets can be readily assembled by vacuum bonding. In the head shown in Figure 10, the ink supply channel 37 connects to nozzle aperture 7W via ink chamber 36. Since the supply channel and nozzle aperture are matched in pairs the head may be manufactured using a much simpler structure than that shown in Figure 3. In addition, since it does not incorporate ink channels, it is possible to reduce the faults in bonding to negligible levels and thus increase yield.

In Figure 11, 39 is a linking pipe joining the head and the ink distributor 31 and carrying ink from the ink supply aperture of the distributor to the ink supply aperture 37 of the head. 40 is an ink tank and 41is a linking part that carries coloured ink for the ink tank 40 to ink distributor 31. If this assembly is located in parallel to the platen and a mechanism is attached to move it reciprocally in a shuttle manner, then it will be similar to that shown in Figure 1. Further, if connecting part 41 is rubber or plastic and is elongated, the ink tank and head may be separated and attached externally.

If the ink tank is attached externally, the weight of the head assembly may be reduced and the design of the drive system may be simplified. In Figure 2, there are pale colour nozzles in

addition to the original four colour nozzles, making a total of eight nozzles in a single unit, which facilitates tone adjustment.

(Effects of the invention)

Since, in the present invention, the configuration of the colour nozzles in the head is such that four colours, yellow, magenta, cyan and black, make up a single unit and these units are arranged in a row and the head itself is moved in a reciprocal movement in a shuttle fashion, it is possible to reduce the printing time and to minimise the travel distance of the head and thus to reduce the overall size of the printer.

In the sheets that constitute the head, ink distribution channels, which branch off from the ink supply aperture to carry inks to the different nozzles, are formed by half etching, and this structure reduces the number of constituent sheets, simplifies the manufacture of the head and achieves a reduction in the cost of the head.

Furthermore, the provision of an ink distributor means that the structure of the head is very simple and the cost of manufacture greatly reduced, which means that the yield of head manufacture is greatly improved. If the distributor is manufactured by etching thin sheets, it is possible to form complex ink channels simply and thus to produce a thinner and lighter product.

Since the ink chambers in the head are rectangular in cross-section and the piezo elements opposite them are also rectangular in shape, lamination of the head is simple.

4. **Simple Descriptions of the Figures**

Figure 1 is an oblique view of an embodiment with the inkjet printer head according to the invention mounted. Figure 2 a front oblique view of the head shown in Figure 1. Figure 3 is an exploded structural view of the head according to the invention. Figure 4 is s schematic sectional view of the head shown in Figure 3. Figure 5 is an exploded structural drawing of another embodiment of the head according to the invention. Figure 6 is a schematic sectional drawing of the head shown in Figure 5. Figure 7 is a sectional view of a head to describe the prior art. Figure 8 is an exploded structural drawing of the head shown in Figure 7. Figure 9 is an exploded structural drawing of the ink distributor. Figure 10 is an exploded structural drawing of another embodiment of the head according to the invention. Figure 11 is a sectional view of a head assembly incorporating the ink distributor shown in Figure and the head shown in Figure 10.

In the figures, 2 is paper, 3 is a head, 4 is a piezo element, 7 is a nozzle, 8 is a head

constituent sheet, 9 is an ink chamber, 10 is a branch ink channel, 11 is an ink channel, 12 is an ink supply aperture, 21 is an ink distribution channel formed by etching, 22 is a distributor constituent sheet, 25 is an ink supply aperture, 31 is a distributor constituent sheet, 32 is a supply aperture, 33 is a branch ink channel, 34 is an ink channel, 35 is an inlet-side ink supply aperture, 36 is an ink chamber and 37 is an ink head supply aperture.

Name of patent applicant: Hitachi Koki Company Limited